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FORECASTING CORN EAR WEIGHT USING SURFACE AREA AND VOLUME VARIABLES: A FINAL REPORT

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FORECASTING CORN EAR WEIGHT USING SURFACE AREA AND VOLUME VARIABLES: A FINAL REPORT, by Fatu Wesley, Research and Applications Division, National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, D.C. 20250, December, 1990. Research Report No. SRB-90-13.

ABSTRACT

The 1988 Corn Ear Weight Study continued to analyze the forecast performance of models estimated using surface area and volume variables to predict final corn ear weight. The initial study used data collected in Michigan in 1986 and 1987. The 1988 study was expanded to Missouri to evaluate the performance of the surface area and volume models in a corn environment that is more drought prone than Michigan. Two models based on diameter measurements were compared to models estimated using the operational procedures from the Corn Objective Yield Survey. The 1988 Results show that the research models have mean square errors that are 40 to 57 percent lower than models estimated using the operational procedure. These results support the findings of the earlier study which indicate that the research models have a superior performance in both normal and drought years. Incorporation of a surface area or volume ear weight estimator should improve the new Corn Objective Yield Models.

ACKNOWLEDEMENTS

The author would like to thank staff and field enumerators of the Michigan and Missouri State Statistical Offices for making thisproject possible. Support provided by George Hanuschak, Benjamin Klugh and William Iwig is appreciated. The author also thanks staff of the Survey Management Section for providing assistance with the project and Tom Birkett for constructive suggestions.

Washington, D. C. December, 1990

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SUMMARY

Forecasts of corn yield, acreage and production are obtained from the Corn Objective Yield Survey, which is conducted by the National Agricultural Statistics Service. Forecasts of ear weight and number of ears are used to predict yield per acre. The purpose of the Corn Ear Weight Study was to develop a more accurate ear weight estimator using surface area and/or volume variables for the corn ear in addition to ear length measurements made in the operational program. Diameter measurements made one inch from the butt of the cob and two inches from the tip of the cob, and length measurements over the cob were used to compute the surface area and volume variables.

The research project was carried out in Michigan in 1986 and 1987. The project was expanded to include both Michigan and Missouri in 1988. Missouri was included in 1988 to determine if the superior performance of the research models in Michigan hold in a corn environment that is more prone to drought. 1988 turned out to be a drought year in both states, therefore the 1988 results provide valuable information about the ability of the models to predict ear weight under different environmental conditions.

Two research models were estimated using surface area and/or volume variables in the 1988 study. These models were also estimated in the 1986 and 1987 study. Results in both states show that the research models have mean square errors that are 40 to 57 percent lower than those for the operational models. The 1988 results, which support findings of the 1986 and 1987 study, indicate that the diameter models forecast ear weight with greater accuracy in both normal and drought years. Therefore, it is recommended that the new diameter measurements be added to the Corn Objective Yield Program in the 1991 crop year. Data will need to be collected for a few years in order to build the models before actual implementation.

Forecasting Corn Ear Weight Using Surface Area and Volume Variables: A Final Report

Fatu Wesley[1]

INTRODUCTION

The 1988 Corn Ear Weight Study, a continuation of the 1986 and 1987 study, examined an alternative method of forecasting corn ear weight. The goal of the study was to develop a method that produces more accurate forecasts of ear weight than the operational method. The current method used by the National Agricultural Statistics Service (NASS) forecasts ear weight based on the length of the ear [4,5]. The method examined in the Corn Ear Weight Study forecasts ear weight based not only on the length of the ear, but more importantly, on its size. Ear size is estimated by computing the surface area or volume of the ear. The 1986 and 1987 results of the ear weight study in Michigan showed that forecasts derived from the research models were closer to the final ear weights than forecasts based on the operational model [1].

The project continued in Michigan in 1988 and was also expanded to Missouri to evaluate the performance of the surface area and volume models in a corn environment that is more drought prone than Michigan.

Table 1 shows NASS official corn yield estimates for Michigan, Missouri and the U.S. for the years included in the study. The yields for 1988 are considerably lower than the 1986 and 1987 yields because 1988 was a drought year. Therefore, results of the 1988 study should show if forecasts based on size are still superior to forecasts based on length, during a drought year.

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[1] The author is a mathematical statistician with the National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, D.C.

Table 1. NASS official corn yield estimates for 1986, 1987 and 1988.

Year	State	Yield(bu/a)
1986	Michigan	105.0
	Missouri	116.0
	U.S.	119.4
1987	Michigan	97.0
	Missouri	113.0
	U.S.	119.8
1988	Michigan	70.0
	Missouri	76.0
	U.S.	84.6

The Corn Ear Weight Study was conducted within the Corn Objective Yield Survey. The Corn Objective Yield Survey is conducted by NASS to forecast corn yield, acreage and production. This monthly probability survey is carried out from August to November. The survey provides forecasts of ear weight and number of ears which are used to forecast yield per acre. The Corn Ear Weight Study examines ear weight, one of the components used in the yield forecast[6]. The Corn Objective Yield Manuals [4,5] and the preliminary report[1] on the Corn Ear Weight Study give a detailed description of the methods used to obtain an ear weight forecast in the operational program.

In this report "initial study" will refer to the 1986 and 1987 study and "final study" will refer to the 1988 study.

METHODOLOGY

Data Collection

Data used in the 1988 study and in the initial study were collected during the September 1 and October 1 survey periods in Michigan and the August 1 and September 1 survey periods in Missouri. The data were collected during these months because the maturity categories used in the study occur during these months. These categories were 4 (milk), 5 (dough) and 6 (dent). Maturity category 3 was excluded because of the assumption that size of the corn ear, at this stage of maturity, was not large enough to show a significant relationship to the final ear weight.

In the initial study enumerators examined the first five ears of corn next to a designated unit to determine the average maturity of the corn. They measured an ear in the unit if the maturity classification of the sample field was 1) 4, 5, or 6, based on the maturity of the first five ears of corn beyond a specified unit and 2) if the maturity category of the individual ear within the unit was 4, 5 or 6. In the 1988 study an ear was measured if the sample unit in which it existed met the first condition, which is the criterion used for establishing maturity of a sample unit in the operational program. It is assumed that eliminating condition (2) in 1988 did not create inconsistency in the data collected over the years. The data for both the initial and final studies probably included a small number of stage 3 ears because each ear in the unit was not examined individually during the final study and although each ear was examined in the inital study, it is sometimes difficult to determine the maturity of an ear without pulling back the husk.

In the initial study, enumerators made three measurements, over the husk, on ears in row 1 of each unit. The measurements were: length of the kernel row, diameter of the cob two inches from the tip, and diameter of the cob one inch from the butt. The kernel row length measurement was made using a tape measure and the butt and tip diameter measurements were made using a vernier caliper. In the final study, the kernel row measurement was replaced with the cob length measurement, which is made in the operational program. The replacement was made because the kernel row measurement(over the husk) did not show a more significant relationship to ear weight than the cob length measurement, which is easier to make. The appendix contains questionnaires used for data collection in 1988.

Forecast Model Development

In the operational program, the ear weight models are estimated within maturity categories. In both the initial and final studies, the operational and research models were estimated across maturity categories because of lack of sufficient data. The models estimated are described below.

Research Models

Research models for forecasting final ear weight had the same form in both the initial and final studies. The models used surface area, volume or length of the corn ear as independent variables. A model had to have a volume and/or surface area variable.

Surface area and volume computations used a diameter measurement and a length measurement. The diameter measurements were made one inch from the butt of the cob(BD) and two inches from the tip(TD). The length measurements were made on the cob over the husk(HL).

All measurements took place in row 1 of both units, except for HL which is an operational program measurement. HL was measured in row 1 of unit 2. Sample averages were computed for the measurements.

The definition of a model was

$$Y_i = \beta_o + \beta_1 X_{1i} + \beta_2 X_{2i} + e_i$$

where,

Y_i=final ear weight for the ith sample field,

$X_{1i,}$ X_{2i} = surface area, volume, or length variable, and,

e_i = the difference between final ear weight and the estimate produced by the model.

The method for estimating the models was Least Squares. For inference purposes, this method assumes that Y_i has a normal distribution with mean $\beta_o+\beta_1X_1+\beta_2X_2$ and variance σ^2; and that e_i has a normal distribution with mean 0 and variance σ^2.

Two research models were estimated. These models are referred to as R1 and R2. Both models were estimated in the initial study. The models are:

Model R1: $\text{Ear Weight}_i = \beta_o + \beta_1 S1_i + \beta_2 BT_i + e_i$

Model R2: $\text{Ear Weight}_i = \beta_o + \beta_1 V2_i + \beta_2 BD_i + e_i$

Definitions of variables included in the models are

S1 = HL*BD
V2 = $(HL*TD^2)/4 * \pi$
BT = BD*TD

Where,

BD = diameter of the cob measured one inch from the butt,
TD = diameter of the cob measured two inches from the tip, and
HL = length of the cob measured over the husk.

Model R1 includes a surface area variable, S1, and an interaction variable, BT. Model R2 includes a volume variable, V2, and the butt diameter, BD.

Operational Model

The operational model is a weighted average of two regression models, the kernel row length(KL) model and the cob length (HL) model. The model is defined as follows:

Let $Y1_i = \alpha_o+\alpha_1(KL)_i + e_{kli}, \quad e_{kl} \sim N(0,\sigma^2_{kl})$

$Y2_i = \beta_o+\beta_1(HL)_i + e_{hli}, \quad e_{hl} \sim N(0,\sigma^2_{hl})$

Then $$Y_i=(a)Y1_i + (1-a)Y2_i \tag{1}$$

where $a=R^2_{Y1i} / (R^2_{Y1i} + R^2_{Y2i})$,

and R^2_{Y1i} = the coefficient of determination for the kernel row length model

R^2_{Y2i} = the coefficient of determination for the husk length model

The operational model referred to as C_S in the paper on the initial study [1] is referred to as CURRENT in this paper. The model estimated in (1) differs from the actual operational model in that the actual operational model is estimated within maturity category while model CURRENT is estimated across maturity categories because of lack of sufficient data.

The following section gives the methodology used to compare the research and operational models. The research models are not compared to the new operational Corn Objective Yield Models implemented by the Statistical Methods Branch in 1990. This issue is addressed in the recommendations section and will require that the new diameter measurements be collected for several years before they can be incorporated into this new model structure.

Model Validation

Model validation tests were conducted on the research and operational models in order to compare their performance. The tests validated the accuracy of the forecasts and the stability of the model coefficients. Validation for forecasting accuracy was performed because the primary objective in developing the ear weight models was to obtain more accurate forecasts. The stability of the model coefficients was examined to determine if the model relationships are consistent over years and therefore reliable for forecasting.

Accuracy in Forecasting

Two methods were used to validate the models for forecasting accuracy. The methods are referred to as Method I and Method II and are described below. Method I was used in the initial study.

Method I

Method I used data independent of the estimation data for validation. This type of validation gives an indication of the forecasting ability of a model by determining how the model performs using data other than that used for its estimation.

The validation mean square error (MSE) was used to compare the forecast performance of two or more models. This mean square error is computed from the forecast error e_i, which is the difference between Y_i, the final ear weight for the ith sample and $Yhat_i$, the ear weight forecast for the same sample. Computation of the forecast error from independent (validation) data is conducted using coefficients estimated from the base (estimation) data to predict final ear weight. MSE can be expressed as follows:

$$MSE = (1/n) * [\Sigma (e_i)^2]$$

Where,
n = the number of observations in the validation data.

Figure 1 below shows the data used for estimation and validation. Missouri had data for only one year, therefore, a random sample of 1/3 of the data was used for validation.

Figure 1. METHOD I: Data used for estimation and validation of research and operational models

State	Estimation Data Period	# of Obs.	Validation Data Period	# of Obs.
MI	1986 & 1987	261	1988	113
	1988	113	1986 & 1987	261
MO	2/3 of 1988	64	1/3 of 1988	30

Method II

The second method of validation for forecasting accuracy was recommended by NASS's Objective Yield Surveys Section. This method compares the variances of the models but makes no formal distinction between estimation and validation. It is based on the premise that a more accurate estimate of the variance of a model is obtained when all of the data is used for estimation (none is withheld for validation, as is done in Method I).

As stated earlier, the operational model is a weighted average of two regression models, the kernel row length(KL) model and the cob

length (HL) model. The following procedure is used to estimate the variance for this model.

$$\text{Let} \quad Y1_i = \alpha_o+\alpha_1(KL)_i + e_{Y1i}, \qquad e_{Y1} \sim N(0,\sigma^2{}_{Y1})$$

$$Y2_i = \beta_o+\beta_1(HL)_i + e_{Y2i}, \qquad e_{Y2} \sim N(0,\sigma^2{}_{Y2})$$

$$\sigma_{Y1,Y2}= \mathrm{Cov}(e_{Y1},e_{Y2})$$

$$Y_i=(a)Y1_i + (1-a)Y2_i$$

$$\text{Where} \quad a=R^2{}_{Y1i} / (R^2{}_{Y1i} + R^2{}_{Y2i}),$$

$$\text{Then } \mathrm{Var}(Y) =[(a^2)\sigma^2{}_{Y1} + (1-a)^2\sigma^2{}_{Y2} + 2a(1-a)\sigma_{Y1,Y2}]$$

$\sigma_{Y1,Y2}$ is estimated by $\Sigma_i \; r_{Y1i}r_{Y2i}/n$

$$\text{Where } r_{Y1i}= Y1_i - Y1_i \text{ and}$$

$$r_{Y2i}= Y2_i - Y2_i$$

Coefficient Stability

The models were compared for cofficient stability by using an F test [3]. The basis of the F test is a comparison of a model's error sum of squares when the coefficients are assumed to be the same to the error sum of squares when the coefficients are assumed to be different. In order for the F test to be valid, the variances obtained by estimating the model by year have to be equal.

The Barlett test for equality of variances [3] was used to test the assumption of equal variance. The appendix describes both the F test and the Barlett test.

RESULTS

In the previous section the methodology used to estimate the research and operational models were given. This section gives the results obtained from applying the methodology. The first section gives results of comparing the models for accuracy in forecasting and the second section gives the results of comparing the models for coefficient stability.

Model Performance

Results for Methods I and II are given below. In Method I, a portion of the data is used for estimating the models and the rest of the data is used for validation. Method II makes no distinction between estimation and validation. The variances of the models are compared when all of the data is used for estimation.

Method I

Table 2 contains estimation statistics for the research and operational models which were computed using the estimation data given in Figure 1. The table shows that estimation mean square errors (mean square errors from the regression output) of the research models are smaller than those of the operational model and that R^2s of the research models are higher than the operational model's. These results are similar to results found in the initial study [1].

Table 3 gives the validation MSEs of the research and operational models. The table shows that both research models have substantially smaller mean square errors than the operational models for all validation data. The reduction in mean square error when the research models are used is at least 40 percent. These results also support the results found in the initial study [1].

Table 2. METHOD I: Estimation statistics for Objective Yield research and operational models.

State	Year	Independent Variables		Estimation MSE	R^2
MI	1986 & 1987	CURRENT	KL	.00503	.2621
			HL	.00473	.3060
		R1	(S1,BT)	.00222	.6753
		R2	(V2,BD)	.00224	.6730
	1988	CURRENT	KL	.00554	.3342
			HL	.00407	.5113
		R1	(S1,BT)	.00255	.6964
		R2	(V2,BD)	.00247	.7058
MO	1988	CURRENT	KL	.00950	.2099
			HL	.00792	.3414
		R1	(S1,BT)	.00440	.6396
		R2	(V2,BD)	.00436	.6430

Table 3. METHOD I: Validation statistics for Objective Yield research and operational models.

State	Estimation Data	Validation Data	Model	Variables	MSE	Percent Reduction in Forecast Error R1	R2
MI	1986 & 1987	1988	CURRENT	(HL,KL)	.0059716	56.5	57.0
			R1	(S1,BT)	.0026003		
			R2	(V2,BD)	.0025675		
MI	1988	1986 & 1987	CURRENT	(HL,KL)	.0051602	51.5	48.7
			R1	(S1,BT)	.0025003		
			R2	(V2,BD)	.0026473		
MO	2/3 of 1988	1/3 of 1988	CURRENT	(HL,KL)	.0042620	53.8	51.4
			R1	(S1,BT)	.0019670		
			R2	(V2,BD)	.0020713		

Method II

Results given in Table 4 are for Method II, which uses all the data to compute the variances of the models and makes no distinction between estimation and validation. The table shows that the research models have substantially lower variances(43 to 45 percent) than the operational model.

Table 4. METHOD II: Results of model comparisons

State	Model	Variables	σ^2	Percent Reduction In Variance R1	R2
MICHIGAN [2]	CURRENT	(HL,KL)	.00415	44.6	45.1
	R1	(S1,BT)	.002299		
	R2	(V2,BD)	.002284		
MISSOURI	CURRENT	(HL,KL)	.00633	43.4	43.3
	R1	(S1,BT)	.00358		
	R2	(V2,BD)	.00359		

[2] Michigan analysis was conducted using data for three years and Missouri analysis was conducted using data for one year.

Coefficient Stability

This section gives the results obtained when coefficients of the research and operational models were compared to determine if they are stable. This comparison was done for the Michigan models because the Missouri data was for one year only. Table 5 shows the coefficients which were estimated for the Michigan models.

Table 5. Estimated coefficients for the research and operational models.

		COEFFICIENTS		
Model	Variable(s)	1986	1987	1988
R1	S1	.000519	.000386	.000525
	BT	.000104	.000141	.000134
R2	V2	.000103	.000115	.000112
	BD	.010303	.009666	.012002
CHL	HL	.034228	.044579	.053529
CKL	KL	.024564	.032526	.033862

Determining if a model's coefficients are stable involves two steps. First, the variances of the model over time have to be verified to be statistically equal and if they are, an F test is performed to determine if the coefficients are stable.

The equality of the variance over time was determined by conducting the Barlett test [3], which is described in the appendix. The Barlett test concludes that the variances are equal if B, the test statistic, is less than χ^2, the $(1-\alpha)$ percentile of the Chi-square distribution with r-1 degrees of freedom. Table 6 gives the results of the Barlett test. Values of χ^2 are given for $\alpha=.05$ and $\alpha=.10$. The table shows that B is less than χ^2 for all models except the operational husk length model. This means that all models except the husk length model have equal variances, therefore the test for coefficient stability cannot be conducted for the husk length model.

Table 6. Results of testing research and operational models for equality of variance

Model	Variable(s)	SSE 1986	SSE 1987	SSE 1988	B
R1	S1,BT	.25258	.30445	.28040	1.130
R2	V2,BD	.26010	.30380	.27167	.831
CHL	HL	.48381	.73263	.45129	8.856*
CKL	KL	.53651	.75625	.61481	3.880

$\chi^2(\alpha=.05)=5.99$, $\chi^2(\alpha=.10)=4.61$

* Statistically significant

Table 7 provides the results of the F test for coefficient stability [3] which is described in the Appendix. The test concludes that the coeffients are not stable if F', the test statistic, is less than F, the (1-α) percentile of the F distribution with p and (n1+n2+n3-3p) degrees of freedom. The table gives F' for all models except the operational husk length model. A comparison of F' to F shows that the research models exhibit borderline stability while the operational kernel row length model is clearly unstable. The instability of the operational model coefficients may be a contributing factor to the poorer forecasting ability identified previously.

Table 7. Results of testing research and operational models for coefficient stability

Model	Variable(s)	SSE Full	SSE Reduced	F'
R1	S1,BT	.83743	.86485	1.99
R2	V2,BD	.83557	.86464	2.12
CHL	HL	1.66773	1.7827	-
CKL	KL	1.9076	2.0650	5.02*

$F(\alpha=.05)=2.60$, $F(\alpha=.10)=2.13$

* Statistically significant

CONCLUSIONS

The 1988 Corn Ear Weight Study continued the ear weight research which occured in Michigan in 1986 and 1987. In 1988 the study was expanded to Missouri to evaluate the performance of the surface area and volume models in a corn environment that is more drought prone than Michigan; however, both states experienced drought conditions in 1988. The research models estimated using the Michigan data for all three years and the Missouri data for 1988 have mean square errors that are 40 to 57 percent percent lower than those for the operational models. Tests performed on the Michigan data showed that the research models have coefficients that exhibit borderline stability while coefficients of the operational models are clearly unstable. These results support findings from the 1986 and 1987 Michigan study and indicate that the research models predict ear weight with greater accuracy than the operational model in both normal and drought years.

RECOMMENDATION

Ear diameter measurements should be added to the Corn Objective Yield Program beginning with the 1991 crop year. Research indicates that two models utilizing these measurements perform similarly in predicting the final ear weight. The author recommends that the surface area model (R1) be implemented in all ten corn objective yield states because it has a slightly simpler form. In addition, research should be conducted to determine if the principle of using the surface area of the ear, instead of its length, improves the performance of the new Corn Objective Yield Models [2] implemented in 1990 by the Statistical Methods Branch. With this new approach, a regional model sets a regional estimate, and then the state models are constrained to produce forecasts that are consistent with the regional model. Data will be needed in all 10 states for at least 5 years in order to build the regional model. Then 2 additional years of independent data should be used for model testing.

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APPENDIX

Stability of Coefficients

Stability of estimated coefficients over time was analyzed by estimating the coefficients by year and using a statistical test to determine if coefficients estimated for 1986, 1987 and 1988 Michigan models are the same [3]. The test compares the error sum of squares when the coefficients are assumed to be the same with the error sum of squares when the coefficients are assumed to be different. The larger the difference between the two sums, the higher the probability of rejecting the hypothesis that the coefficients are the same. In testing the equality of coefficients in two regression equations, each of which includes two independent variables, the hypothesis tested was:

H_o: $\beta_{o1} = \beta_{o2} = \beta_{o3}$, $\beta_{11} = \beta_{12} = \beta_{13}$, $\beta_{21} = \beta_{22} = \beta_{33}$

H_a: $(\beta_{o1} \neq \beta_{o2} \neq \beta_{o3})$ and/or $(\beta_{11} \neq \beta_{12} \neq \beta_{13})$ and/or $(\beta_{21} \neq \beta_{22} \neq \beta_{23})$

where,

β_{o1}, β_{11}, β_{21} = coefficients estimated for the first regression equation, and
β_{o2}, β_{12}, β_{22} = coefficients estimated for the second regression equation.
β_{o3}, β_{13}, β_{23} = coefficients estimated for the third regression equation.

The null hypothesis is rejected if the test statistic

$$F' = \frac{[SSE(R) - SSE(F)]/p}{SSE(F)/(n1+n2+n3-3p)} \qquad (A1)$$

is greater than $F(1-\alpha;p,n1+n2+n3-3p)$, the $1-\alpha$ percentile of the F distribution with p and n1+n2+n3-3p degrees of freedom. The number of parameters estimated in the regression function is p. The probability of rejecting the null hypothesis given the hypothesis is true is α. In (A1), SSE(R) is the error sum of squares obtained by assuming the coefficients are equal (model called reduced) and estimating the equation all three years. SSE(F) is the error sum of squares obtained by assuming the coefficients are different (model called full). Computation of

SSE(F) involves estimating the equations for each year separately and adding the individual sum of squares. The number of observations for the first, second and third years are n1, n2, and n3, respectively.

The test for determining coefficient stability is based on the assumption that variances of the error terms from the regression for the first year (SSE_1), second year (SSE_2), and third year(SSE_3) are equal. Since there are more than two variances to consider, the Barlett test for the equality of variances [3] was used, instead of the F test, to determine if the models satisfy the assumption of equal variance. The Barlett test concludes that the variances are equal if

$$B \leq \chi^2 (1-\alpha; r-1) \tag{A2}$$

Where,

$B = (2.302585/C)(n_T - r)(\log_{10}MSE - \log_{10}GMSE)$

MSE= the arithmetic mean of the SSE's weighted by the number of observations for each year

GMSE= the geometric mean of the SSE's weighted by the number of observations for each year

n_T= the sum of n1,n2, and n3

r = the number of years

$C = (1 + (1/3(r-1))\{ \Sigma_j (1/(n_j-1))-(1/n_T-r)\}$, j=1 to r

$\chi^2(1-\alpha; r-1)$ is the $(1-\alpha)$ percentile of the Chi-Square distribution with r-1 degrees of freedom.

UNITED STATES DEPARTMENT OF AGRICULTURE
NATIONAL AGRICULTURAL STATISTICS SERVICE

PREHARVEST

Form Approved
O.M.B. Number 0535-0088
Expiration Date 7/31/89
C.E.-120032B-1

FORM B--1: CORN YIELD COUNTS --1988

YEAR,CROP,FORM,MONTH (1-5)
843 __ __

USE FORM B-1 FOR ALL PREHARVEST COUNTS AND MEASUREMENTS

Date (________________________) 370

Starting Time (*military time*) 371

Has operator applied pesticides with organophosphorous content to sample field? ( ) YES ( ) NO

*If YES, enter latest application date*______________*and name of pesticide*______________________.

UNIT LOCATION CODE

1. a. First visit to lay out unit . . . . .Code 1
   b. Unit relocated this month . . . . Code 2
   c. Sample unit laid out previously . . . . Code 3
   } Enter

   Go to Item 3 when coded 3; otherwise go to Item 2.

UNIT 1	UNIT 2
302	307

ROW SPACE MEASUREMENTS

2. a. Measure distance from stalks in Row 1 to stalks in Row 2 . . . . Feet & Tenths
   b. Measure distance from stalks in Row 1 to stalks in Row 5 . . . . Feet & Tenths

UNIT 1	UNIT 2
303 . __	304 . __
305 . __	306 . __

STAGE OF MATURITY

Designated Measurement Areas:

For Month	Use Area Beyond
Aug 1	Unit 1, Row 1
Sept 1	Unit 1, Row 2
Oct 1	Unit 2, Row 2
Nov 1	Unit 2, Row 1

Maturity Stage	Code	Maturity Stage	Code
Pre-Blister	2	Dough	5
Blister	3	Dent	6
Milk	4	Mature	7

Husk the first 5 ears or silked ear shoots beyond the unit in the designated measurement area and examine for maturity. If ears or silked ear shoots are not yet present, CHECK ( ) and complete item 6 only.

3. Maturity stage of first 5 ears or silked ear shoots . . . .

Ear Number 1	2	3	4	5	Total of 5 ears
					301

a. Does Item 3 have 3 or more Code 7 Ears?

OR

Will this field be harvested within the next 3 days?

{ ( ) YES - to either question - Complete B - 2.
( ) NO - to both questions - Continue.

TOTAL OF 5 EARS:		
	12 OR LESS	COMPLETE ITEMS 6 - 9 ONLY.
	13 - 22	COMPLETE ALL ITEMS.
	23 OR MORE	COMPLETE ALL ITEMS EXCEPT 7 AND 8.

NOTE: Copy maturity of ears to corresponding cells in Item 4 on back of form (replace any Code 2 ear shoots with next Code 3 ear or higher).

FORM B--1: CORN (Continued)

	Ear Number 1	2	3	4	5
4. Enter the maturity stage of each of the first 5 ears Code 3 or higher . . . Code	320	321	322	323	324
5. Enter the average length of kernel rows (Item 4 ears) . . . Inches & Tenths	326 •__	327 •__	328 •__	329 •__	330 •__

COUNTS WITHIN 15 FOOT UNITS

	UNIT 1 ROW 1	UNIT 1 ROW 2	UNIT 2 ROW 1	UNIT 2 ROW 2
6. Number of stalks . . .	331	332	333	334
7. Number of stalks with ears or silked ear shoots *(Item 7 cannot exceed Item 6 for any row)* . . .	341	342	343	344
8. Number of ears and silked ear shoots *(Item 8 MUST equal or exceed Item 7 for any row)* . . .	351	352	353	354
9. Number of ears with evidence of kernel formation *(Item 9 cannot exceed Item 8 for any row)* . . .	361	362	363	364

MEASUREMENTS WITHIN UNIT 2, ROW 1

10. Enter the number of ears counted in Item 9 for Unit 2, Row 1 (Cell 363) ________.
Measure length of COB for all EARS counted. The number measured and entered below must equal the number counted in Cell 363.

1. ___•__	6. ___•__	11. ___•__	16. ___•__	21. ___•__	26. ___•__
2. ___•__	7. ___•__	12. ___•__	17. ___•__	22. ___•__	27. ___•__
3. ___•__	8. ___•__	13. ___•__	18. ___•__	23. ___•__	28. ___•__
4. ___•__	9. ___•__	14. ___•__	19. ___•__	24. ___•__	29. ___•__
5. ___•__	10. ___•__	15. ___•__	20. ___•__	25. ___•__	30. ___•__

Total Length	308 •__
Total Ears	309
Ending Time *(Military Time)*	372
Enumerator Number	390
Supervisor Number	391
STATUS CODE	380

Enumerator ________________________

Did your supervisor assist you in working this sample?
( ) YES, ( ) NO

UNITED STATES DEPARTMENT OF AGRICULTURE
NATIONAL AGRICULTURAL STATISTICS SERVICE

Form Approved
O.M.B. Number 0535-0088
Expiration Date 7/31/89
C.E.-120032B-R

Michigan
Missouri

FORM B--R: CORN RESEARCH STUDY --1988

YEAR,CROP,FORM,MONTH (1-5)	
843	

1. Does Form B - 1, item 3, have 3 or more code 7 ears

   OR

   Will the field be harvested within 3 days? ( ) YES -- Go to Form B - 2.
   ( ) NO -- Continue.

2. Is the total of 5 ears given on Form B - 1, Item code 301, 18 or greater?

   ( ) YES - Tag the 3rd and 4th ears in row 1 of each unit with the ID tags provided. Complete Item 3.

   ( ) NO - Return to Form B - 1.

MEASUREMENTS

3. Measure:

The length of the cob. Record to the nearest 1/10 inch.
The diameter of the ear one inch from the butt of the cob. Record to nearest 1 millimeter.
The diameter of the ear two inches from the tip of the cob. Record to nearest 1 millimeter.

UNIT 1, ROW 1

U	Ear No.	Cob Length (to 1/10 inch)	Butt Diameter (to 1 mm)	Tip Diameter (to 1 mm)
1	1.	.__		
.1	2.	.__		
1	3.	.__		
1	4.	.__		
1	5.	.__		
1	6.	.__		
1	7.	.__		
1	8.	.__		
1	9.	.__		
1	10.	.__		

UNIT 2, ROW 1

U	Ear No.	Cob Length (to 1/10 inch)	Butt Diameter (to 1 mm)	Tip Diameter (to 1 mm)
2	1.	.__		
2	2.	.__		
2	3.	.__		
2	4.	.__		
2	5.	.__		
2	6.	.__		
2	7.	.__		
2	8.	.__		
2	9.	.__		
2	10.	.__		

If more than 10 ears, continue on back.

FORM B--R CORN (CONTINUED)

UNIT 1, ROW 1

U	Ear No.	Cob Length (to 1/10 inch)	Butt Diameter (to 1 mm)	Tip Diameter (to 1 mm)
1	11.	.__		
1	12.	.__		
1	13.	.__		
1	14.	.__		
1	15.	.__		
1	16.	.__		
1	17.	.__		
1	18.	.__		
1	19.	.__		
1	20.	.__		
1	21.	.__		
1	22.	.__		
1	23.	.__		
1	24.	.__		
1	25.	.__		
1	26.	.__		
1	27.	.__		
1	28.	.__		
1	29.	.__		
1	30.	.__		

UNIT 2, ROW 1

U	Ear No.	Cob Length (to 1/10 inch)	Butt Diameter (to 1 mm)	Tip Diameter (to 1 mm)
2	11.	.__		
2	12.	.__		
2	13.	.__		
2	14.	.__		
2	15.	.__		
2	16.	.__		
2	17.	.__		
2	18.	.__		
2	19.	.__		
2	20.	.__		
2	21.	.__		
2	22.	.__		
2	23.	.__		
2	24.	.__		
2	25.	.__		
2	26.	.__		
2	27.	.__		
2	28.	.__		
2	29.	.__		
2	30.	.__		

* U.S. G.P.O:1990-281-097:40003/NASS